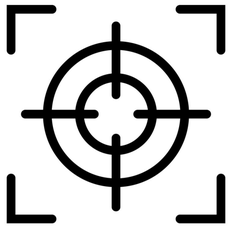
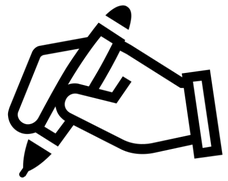
Topic 4:
Nutrition in Human

Chapter Analysis



FOCUS

- heavy content but straightforward



EXAM

- commonly tested in MCQ and structured questions

WEIGHTAGE

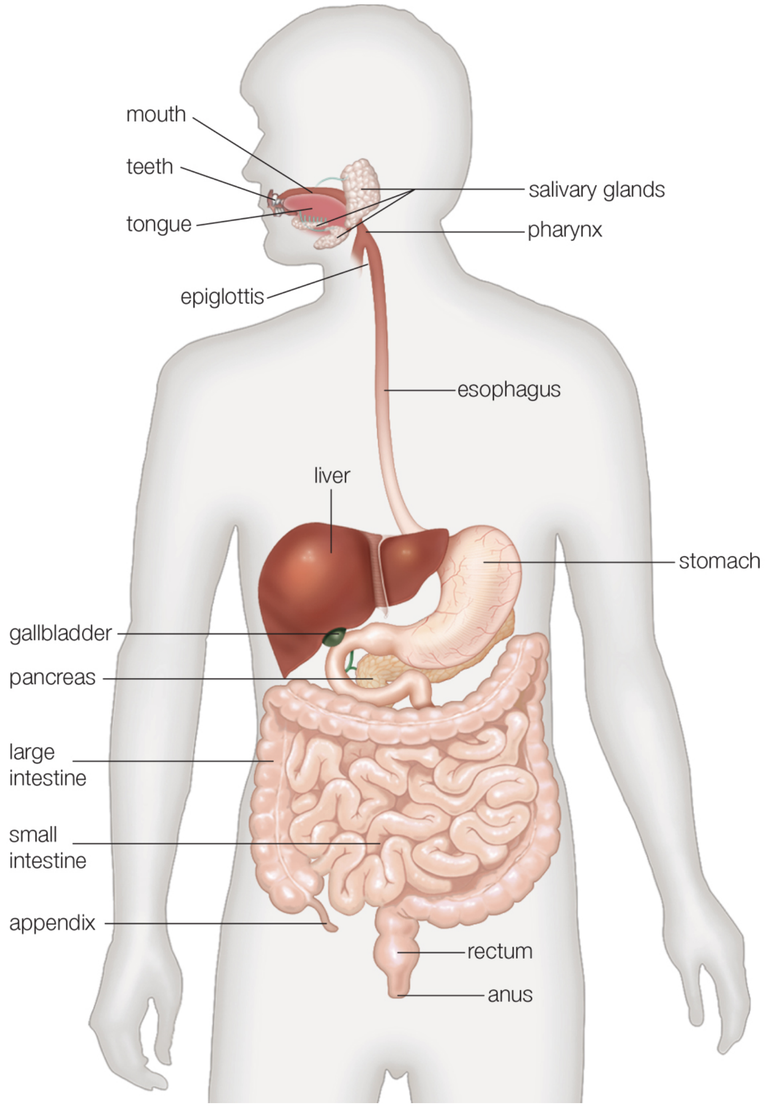
- Constitute to around 5% in Paper 2 in the past 5 years

Key Concept

Digestive System
Digestion

Carbohydrate, proteins and fats are broken down into soluble glucose, amino acids, fatty acids and glycerol

Overview of digestive system



1. Mouth and buccal cavity

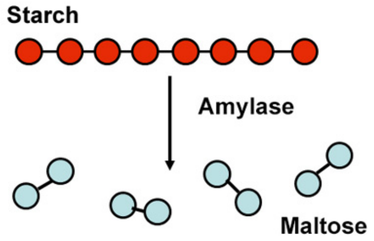
(a) Teeth: chewing, breakdown large pieces of food to smaller size.

- I**ncrease surface area to volume ratio of the food** that enzyme can act on more efficiently.

(b) Salivary glands: Secrete saliva into mouth via salivary ducts.

- saliva contains **salivary amylase** that **digest starch to maltose**

(c) Tongue: mix food with saliva into bolus

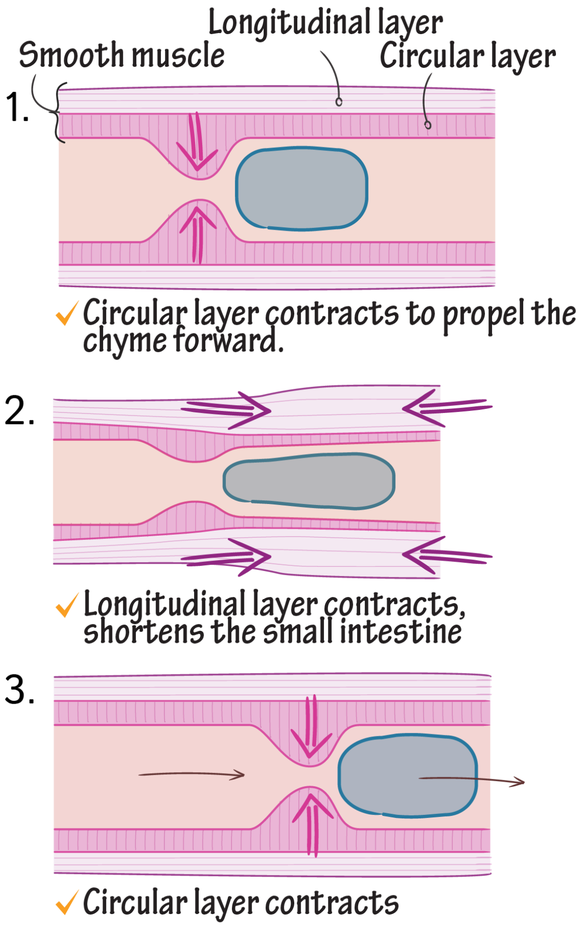


2. Oesophagus

- A narrow muscular tube that connects the buccal cavity and stomach
- It is made up of two layers of muscle. The external layer is the **longitudinal muscle** and the inner layer is the **circular muscle**.

Overview of digestive system

Peristalsis

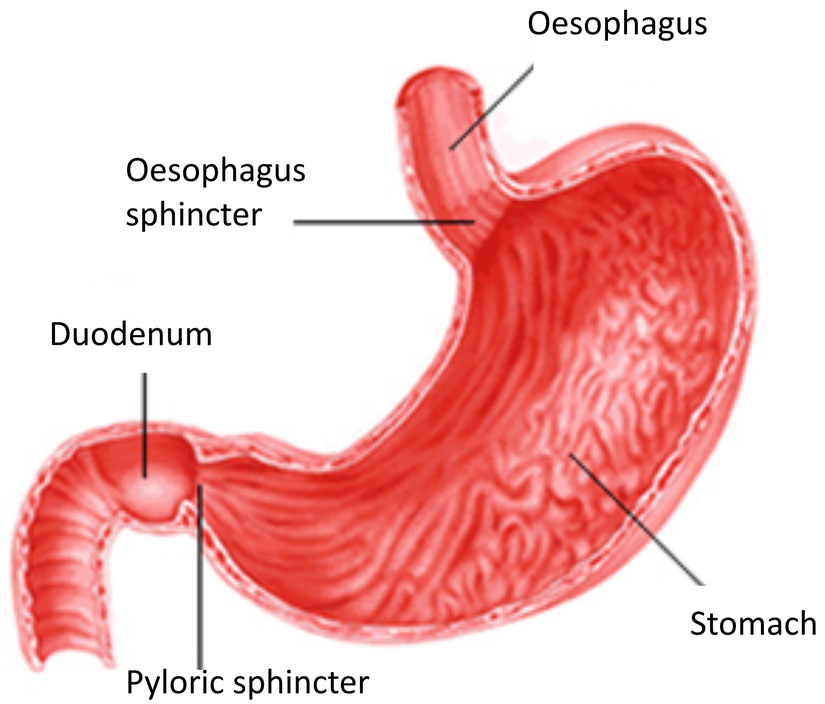


Peristalsis

- **Rhythmic wave-like contractions** of the muscles
- Peristalsis allows mixing of food and digestive juices and propel the contents of the alimentary canal
- The circular and longitudinal muscles are **antagonistic** muscles.
- When the **circular muscles contract**, the **longitudinal muscles relax**. As a result, the wall of the gut **constricts**, and the gut becomes narrower and longer. The food is **pushed forward**.
- When the **longitudinal muscles contract**, the **circular muscles relax**. The gut **dilates**, and it becomes wider and shorter. This widens the lumen for **food to enter**.
- These muscles found along much of the entire length of the alimentary canal (oesophagus, stomach, small intestine, large intestine)

Overview of digestive system

Stomach



Stomach wall has pits that lead to **gastric gland**, which secretes

(1) mucus which protects the stomach walls

(2) gastric acid/dilute hydrochloric acid

- Gastric acid is pH 2, **denatures salivary amylase** thus stop its activity
- changes the **inactive pepsinogen into the active form, pepsin**
- provides an acidic environment as pepsin **optimum pH** is 2
- **kills germs and bacteria.**

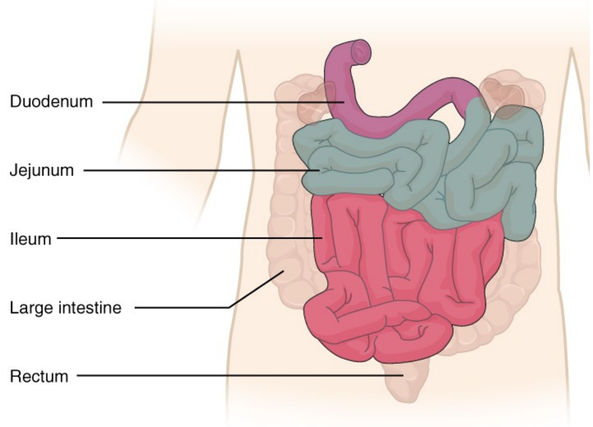
(3) pepsinogen (inactive form)

- dilute HCl activates pepsinogen to pepsin
- pepsin **digest proteins to polypeptides**

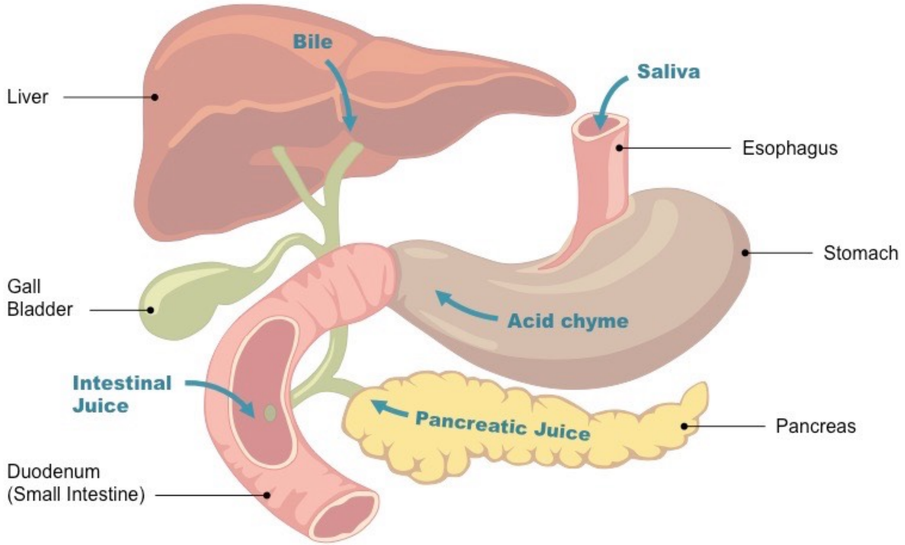
- Food normally remains in the stomach for about three to four hours. The partly digested food becomes liquefied, forming chyme.
- The pyloric sphincter is located at the place where the stomach joins the small intestine. When the muscle contracts, the entrance to the small intestine closes. When the ring relaxes, chyme passes in small amounts into the duodenum

Overview of digestive system

Small Intestine



- The small intestine is divided into three parts: the duodenum, jejunum and ileum.
- In the duodenum, chyme from the stomach mixes with
    1. **Pancreatic juice** secreted from pancreas
    2. **Intestinal juice** secreted by epithelial cells of small intestine
    3. **Bile** from gall bladder
- all three juices are alkaline, thus they neutralise the acidic chyme from stomach and provide an optimum alkaline environment for pancreatic and intestinal enzymes

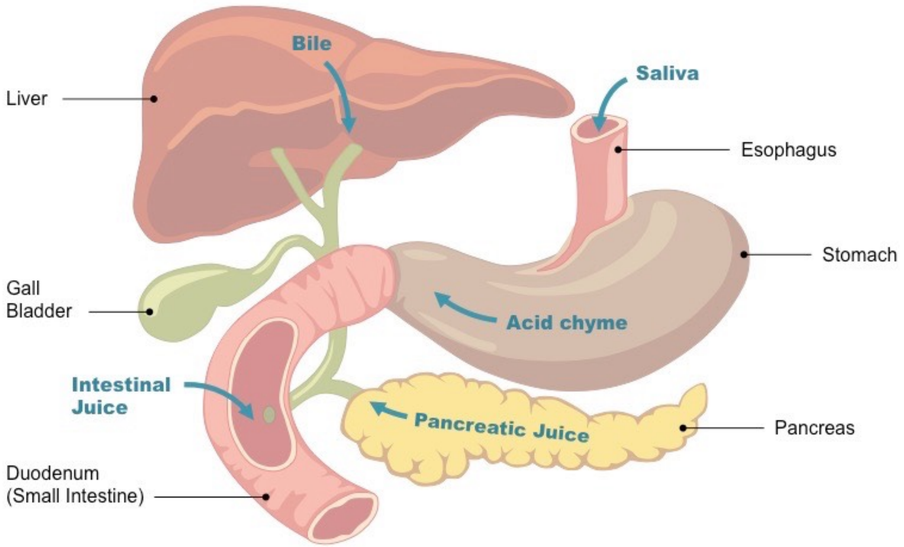


BILE

- Bile is produced by the liver and stored in the gall bladder.
- It passes into the small intestine through the bile duct.
- Bile **emulsifies large fat droplets** into **smaller** fat droplets, **increasing** the **surface area to volume ratio** of the fats for **lipase** to work on and **speeds up fat digestion**

Overview of digestive system

Small Intestine



- Enzymes found in pancreatic juice: trypsinogen, pancreatic amylase and pancreatic lipase
- Enzymes found in intestinal Juice: enterokinase, erepsin, maltase, lactase, sucrase, intestinal lipase

Proteins

Trypsinogen (inactive) —(enterokinase)→ Trypsin (active)

Proteins —(trypsin)→ Polypeptides

Polypeptides —(erepsin / peptidases)→ Amino acids

Carbohydrate

Starch —(pancreatic amylase)→ Maltose

Maltose —(maltase)→ Glucose + Glucose

Lactose —(lactase)→ Glucose + Lactose

Sucrose —(sucrase)→ Glucose + Fructose

Fats

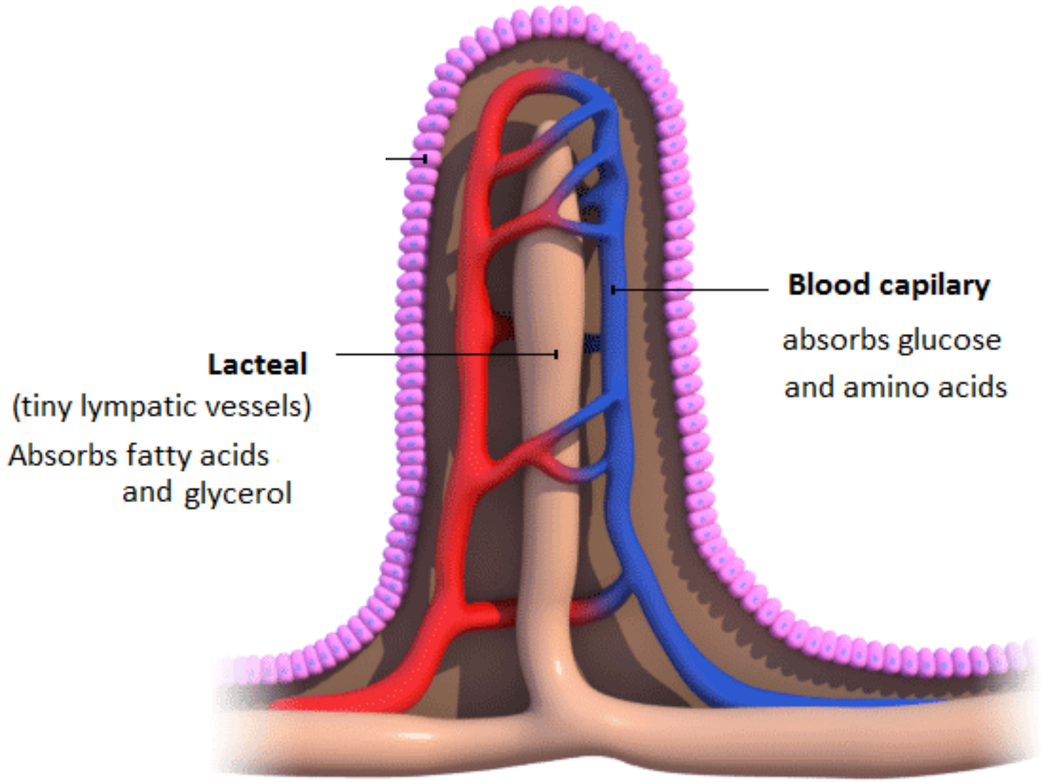
Fats —(pancreatic lipase/ intestinal lipase)→ Fatty acids + glycerol

Key Concept

Absorption

Glucose, amino acids, fatty acids and glycerol are absorbed into body cells

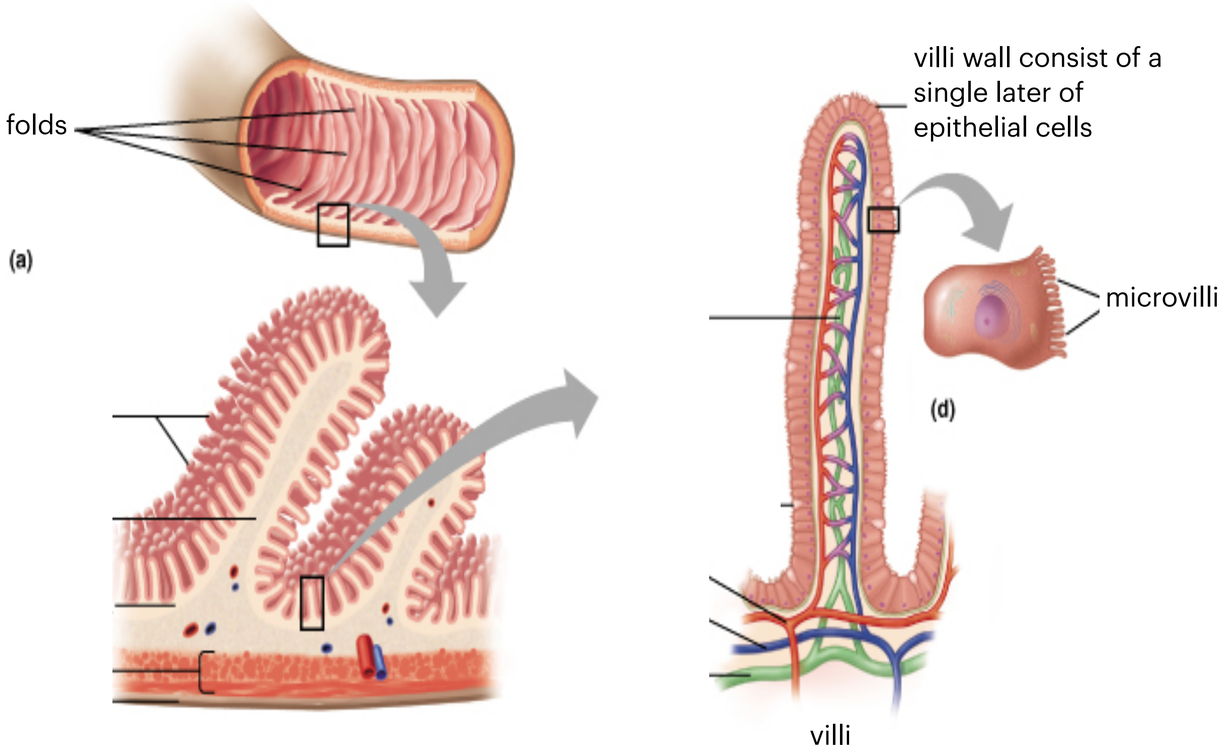
Absorption



- Nutrients are absorbed across the wall of the small intestine and into the capillaries or lacteal.
- **Glycerol and fatty acids** are absorbed by the epithelial cells of the villi and **recombined** within those cells to **form fats**, which are transported into a **lacteal**.
- **Glucose and amino acids** are absorbed by **diffusion or active transport** into the **blood capillaries** depending on the concentration gradient.
- **Water** is absorbed by passive **diffusion** throughout the length of the small intestine and mineral salts are absorbed in the ileum.

adaptation of small intestine

function: digestion and absorption (focus)



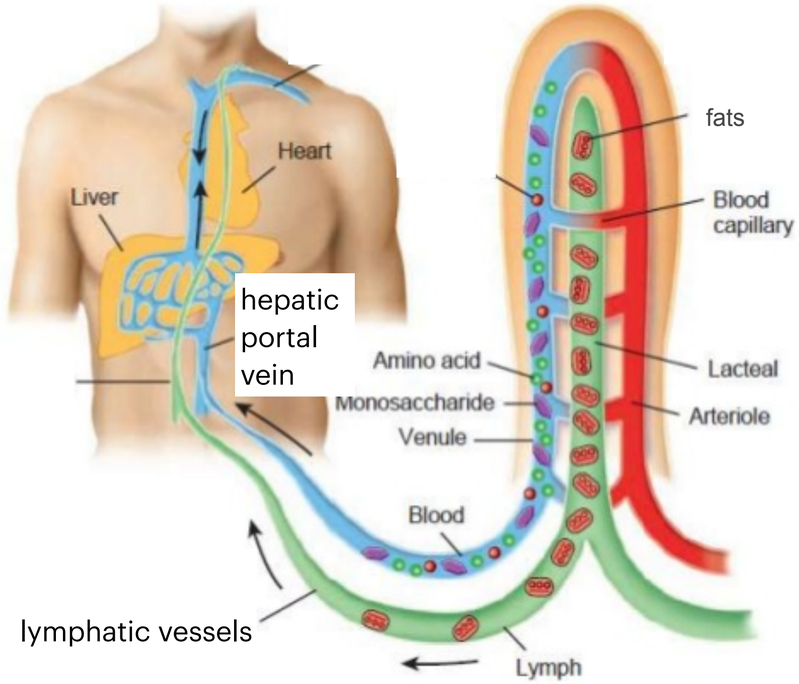
Structure	Adaptation
• There are many large **fold** at the inner wall of small intestine • **Villi** are finger like projections that are present on the folds • **Microvilli** are present on each epithelial cells of villi	**Increase surface area to volume ratio** for absorption of food nutrients by small intestine
Villi wall is only o***ne cell thick***	**Reduce distance** for digested nutrients to diffuse into blood vessels or lacteal
Within each villus is a **network of capillaries and lacteal**	Continuous transport of digested food substances **maintains the steep concentration gradient** of nutrients for diffusion

Key Concept

Assimilation

Absorbed nutrients are utilised by body

Assimilation



- **blood capillaries** of the villi **converge** into a large blood vessel called the **hepatic portal vein**, which then transport **glucose and amino acid** to the liver
- **lacteal or lymphatic capillaries** join to form larger **lymphatic vessels**, which discharge fats into the bloodstream.

glucose	- Glucose is assimilated and then oxidised during tissue respiration to release energy for the vital activities of the cells. - Excess glucose is returned to the liver and stored as glycogen.
amino acids	- Amino acids which enter the cells are converted into new protoplasm that is used for growth and repair of worn-out parts of the body. - Amino acids are used to form essential proteins such as enzymes and hormones - Excess amino acids are deaminated in the liver.
fats	- When there is a sufficient supply of glucose, fats are not broken down, but are used to build protoplasm. - When glucose is in short supply, fats are broken down to provide energy needed by the body. - Excess fats are stored in the adipose tissues beneath the skin and around the vital organs such as heart and kidneys, which act as shock absorbers.

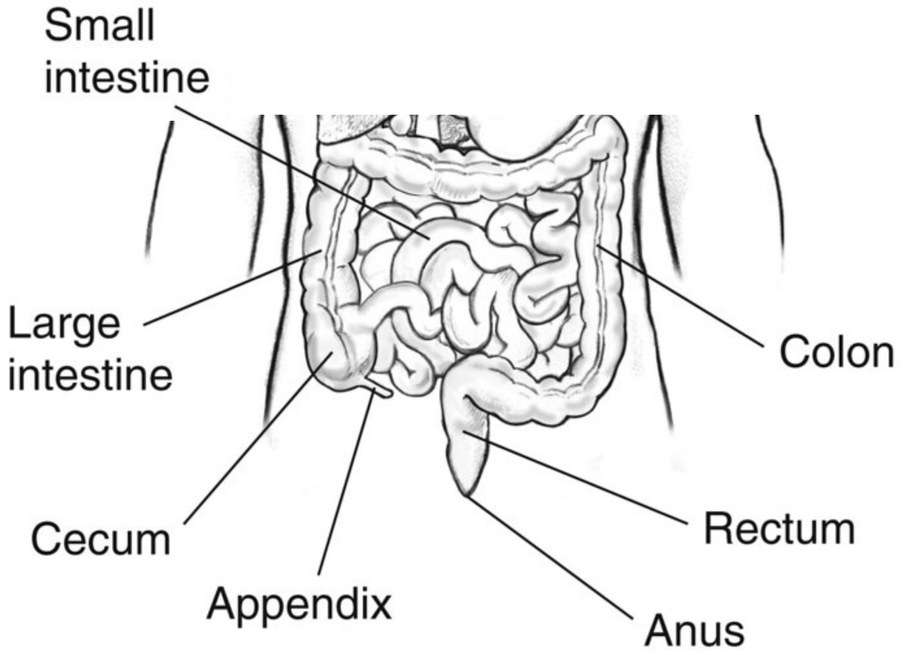
Key Concept

Egestion

Removal of undigested food out of body

Egestion

Large Intestine

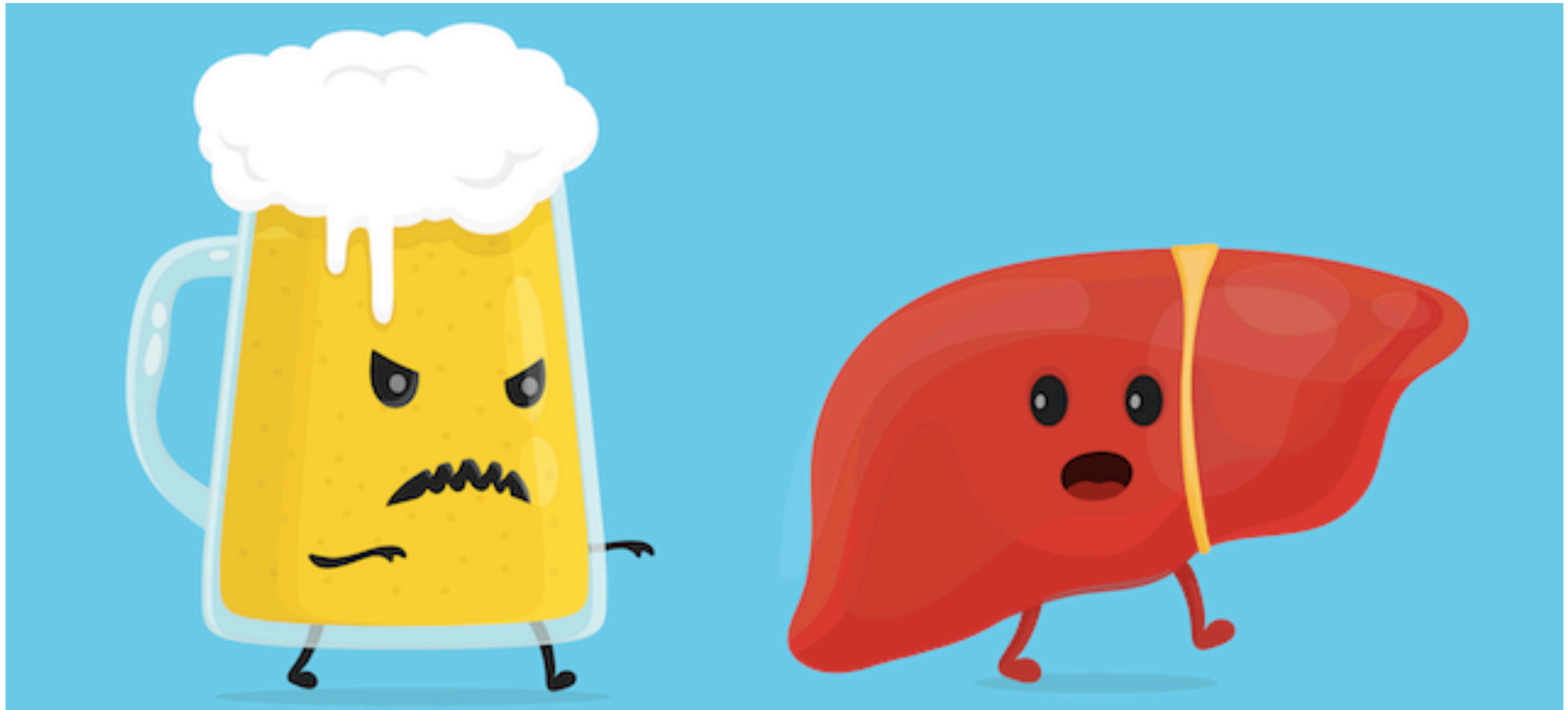


5. Large Intestine

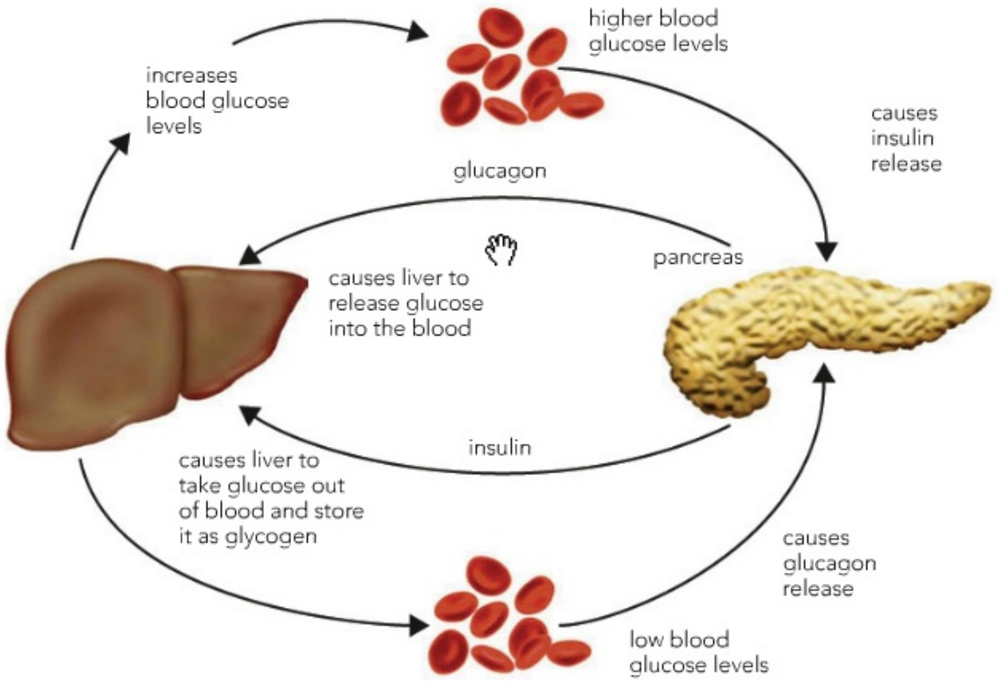
- The large intestine serves to **absorb the remaining water and mineral salts** that have not been absorbed by the small intestine (most of the water had been absorbed by the small intestine)
- **No digestion** occurs in the large intestine
- The undigested waste matter comprises mainly cellulose, which is indigestible to humans.
- Faeces is temporarily **stored in rectum**. When the rectrum contracts, the faeces is then expelled through the anus.

Key Concept

Liver
Effect of alcohol



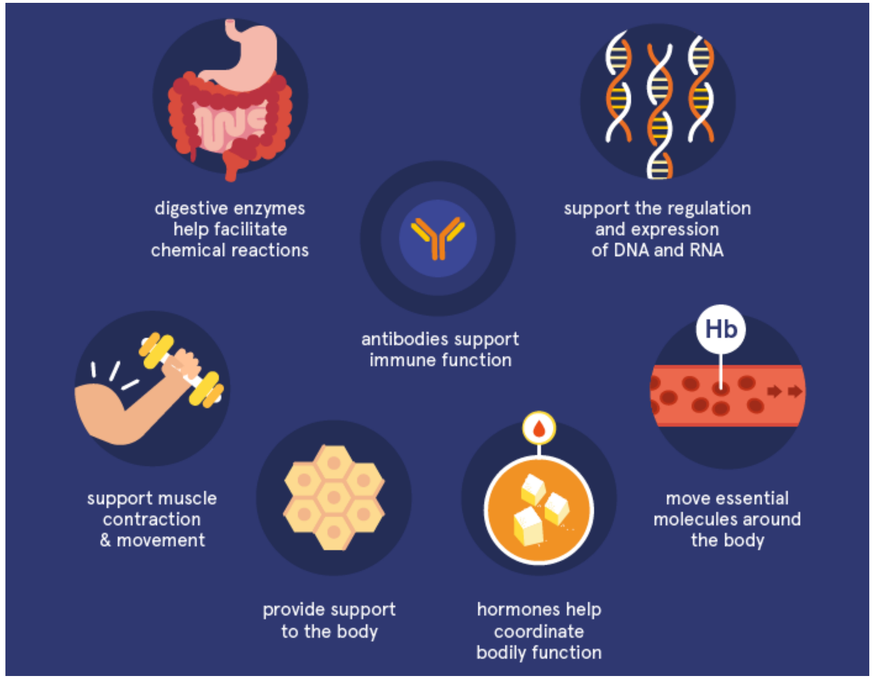
Function of liver



1. **Regulation of blood glucose concentration (carbohydrate metabolism)**

- When blood glucose is higher than normal, the islets of Langerhans in the pancreas will secrete insulin. Insulin will stimulate liver cells to convert excess glucose to glycogen and stored in liver. This decrease blood glucose level back to normal.
- When blood glucose level is lower than normal, the islets of Langerhans in the pancreas will secrete glucagon. Glucagon stimulates the liver cells to convert stored glycogen in the liver back into glucose. The glucose is released into the blood, which increase blood glucose level back to normal.

Function of liver

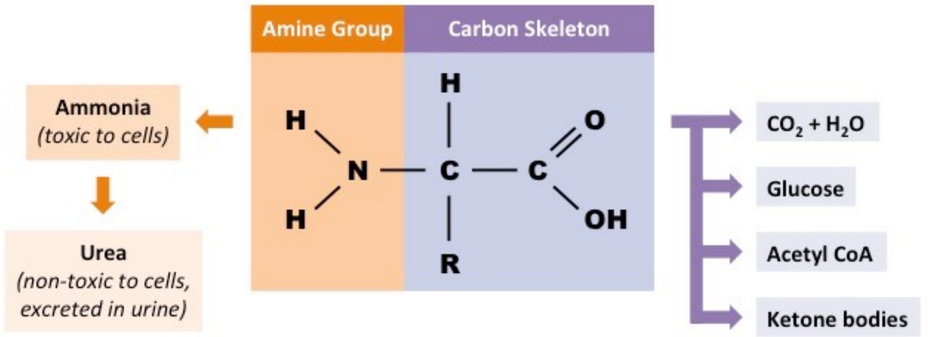


2. metabolism of amino acids

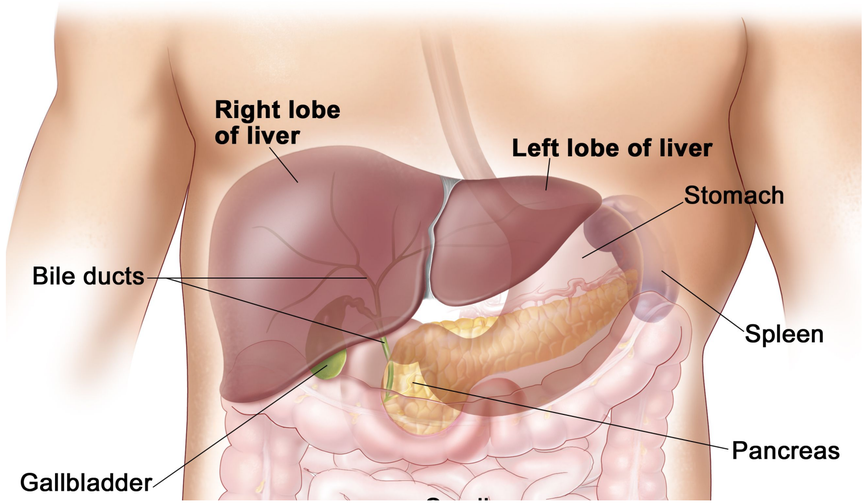
- The liver synthesis essential proteins from amino acids in the diet, including blood clotting proteins like prothrombin and fibrinogen.

3. Deamination

- Excess amino acid is deaminated by the liver, which is the removal of the amino group ($-NH_2$) from an amino acid.
- The amino group is first converted into ammonia, which is toxic to cells, then converted to urea by enzymes in the liver, and eventually removed in urine.



Function of liver



4. Production of bile (fat digestion)

- Liver produces bile that is stored temporarily in the gall bladder
- Bile flows into the duodenum via the bile duct.
- Bile emulsifies large fat droplet into smaller droplet, increase the surface area to volume ratio for lipase to act on, increasing efficiency of digestion

5. Iron storage

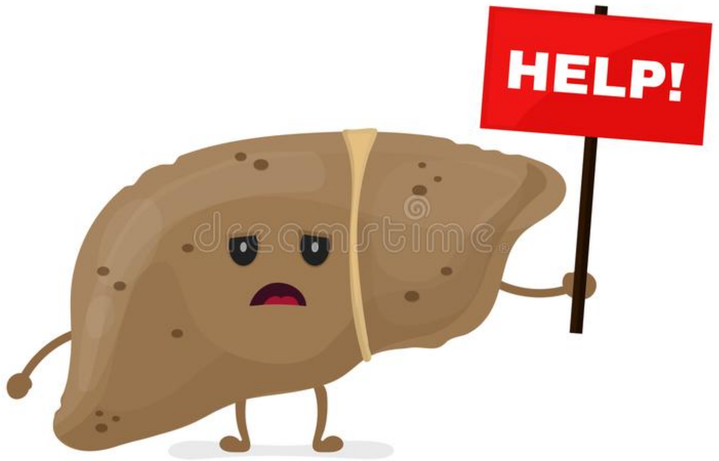
- Spleen destroys aging red blood cells.
- Haemoglobin in red blood cells is transported to liver and broken down. The iron content is stored in the liver
- Other metabolic by-products of the breakdown form bile pigments.

Function of liver

$$Alcohol \xrightarrow{Alcohol\ dehydrogenase} Acetaldehyde \xrightarrow{Acetaldehyde\ dehydrogenase} Acetic\ acid$$

6. Detoxification

- The liver breaks down **toxic substances** for **excretion** in urine or bile.
- E.g. alcohol is broken down **acetaldehyde**, catalysed by **alcohol dehydrogenase**.
- **Acetaldehyde** is then converted to harmless **acetic acid** by **acetaldehyde dehydrogenase.**



<u>Effects of excessive consumption of alcohol:</u>

- Alcohol irritates oesophageal, stomach and intestinal linings, leading to inflammation and ulcers
- When liver cells are inflamed and damaged, liver cells are replaced with fibrous scar tissues. This is called liver cirrhosis.
- Liver function is lost - reduced ability of previous 6 functions has very serious complications
- Alcohol is also a depressant, which inhibit the central nervous system (CNS), impairs and slows the activity of the brain and nervous system leading to a slower reaction time and reduced self control.
  - Greater risk taking and poor decision making
  - vulnerable to unintentional accidents and injuries.

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